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Polarization Reconfigurable Patch Antenna Using Microelectromechanical Systems (MEMS) Actuators

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POLARIZATION RECONFIGURABLE PATCH ANTENNA USING MICROELECTROMECHANICAL SYSTEMS (MEMS) ACTUATORS

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I. INTRODUCTION

The capability to dynamically reconfigure the radiation patterns of planar antennas through geometric reconfiguration is essential for undertaking diverse missions [1]. This is made possible through the use of microelectromechanical systems (MEMS) based switching and actuating devices or circuits. The MEMS devices offer the following advantages over semiconductor devices: (1) significant reduction in insertion loss, (2) they consume an insignificant amount of power during operation, and (3) higher linearity hence lower signal distortion. Typical examples of MEMS based antennas are reported in [2] to [8].

In this paper, we present the first ever polarization reconfigurable patch antenna via use of integrated MEMS actuator. The key feature of this approach is: (1) the ability of a nearly square patch to dynamically reconfigure the polarization from circular to linear, thus providing polarization diversity and (2) the MEMS actuator is housed within the patch and does not require additional space. This feature is particularly important in the construction of a N by N planar array antenna with small inter-element spacing.

II. MEMS ACTUATOR INTEGRATION AND OPERATION

A nearly square patch antenna with integrated MEMS actuator is shown in Fig. 1. Briefly the actuator consists of a moveable metal overpass suspended over a metal stub. The overpass is supported at both ends by metalized vias which are electrically connected to the nearly square patch antenna. The metal overpass is actuated by an electrostatic force of attraction set up by a voltage applied between the overpass and the metal stub. A dielectric film deposited over the metal stub prevents stiction when the surfaces come in contact. The design of the MEMS actuator is presented in [2]. The MEMS actuator as viewed from the top is shown in the photomicrograph in Fig. 1.

The nearly square patch antenna with notches illustrated in Fig.1, is designed to support two degenerate orthogonal modes when excited at a corner [9], [10]. When the MEMS actuator is in the OFF-state the perturbation of the modes is negligible and hence the patch radiates a circularly polarized (CP) wave. When an electrostatic force resulting from the application of a bias pulls down the overpass, the MEMS actuator is in the ON-state. This action perturbs the phase relation between the two modes causing the patch to radiate dual linearly polarized (LP) waves.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

The measured return loss for the OFF-state of the actuator is shown in Fig. 2. The patch is well matched to the 50Ω feed line and resonates at a frequency of 26.7 GHz. In the OFF-state the patch radiates a circularly polarized wave. To measure the radiation patterns, the RF probe station is modified to accommodate an open-ended rectangular waveguide (WR-42) as the rotating linearly polarized receiving antenna. The open-ended waveguide is attached to a Plexiglas™ fixture and is driven along an arc by a stepper motor. Thus the spinning open-ended waveguide can measure the relative field intensity of the patch as a function of the angle from boresight. The experimental setup is illustrated in Fig. 3. The measured radiation patterns along the two orthogonal planes are shown in Fig. 4. The measured axial ratio at boresight is about 2.0 dB.

The measured return loss for the ON-state of the actuator is also shown in Fig. 2. In the ON-state also the patch is well matched to the 50Ω feed line and resonates at a frequency of 26.625 GHz. The change in the resonance frequency for the two states is considered to be small. In the ON-state, the patch radiates dual linearly polarized waves. The measured E- and H-plane radiation patterns for the vertical polarization are shown in Fig. 5. Similar radiation patterns are observed for the horizontal polarization.

IV. CONCLUSIONS

A novel polarization reconfigurable patch antenna with integrated MEMS actuators is presented for the first time. This patch can be dynamically reconfigured to radiate either a circularly polarized or dual linearly polarized radiation patterns.

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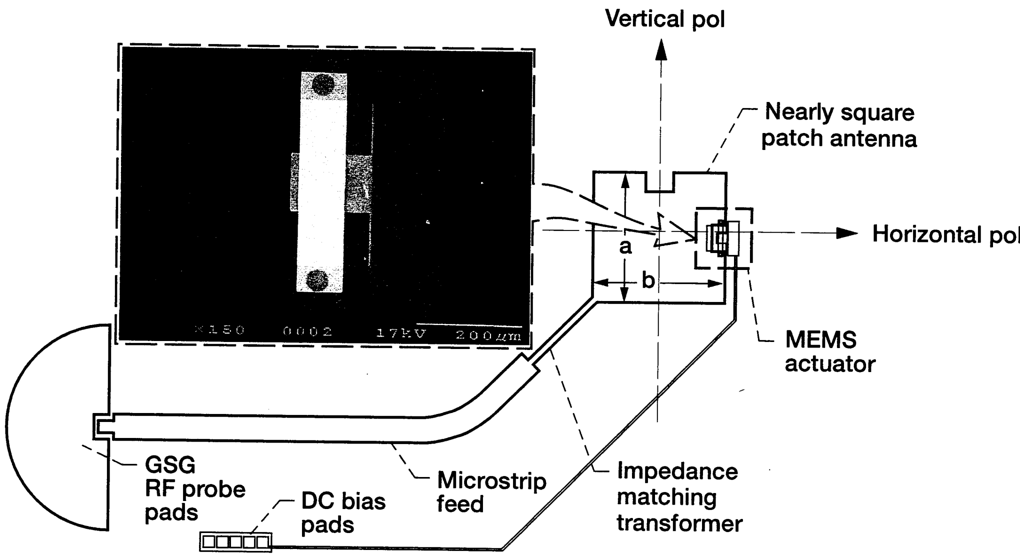

Figure 1.—Polarization reconfigurable patch antenna element with integrated MEMS actuator, a = 1500 µm and b = 1492 µm. Inset shows photomicrograph of the MEMS actuator.

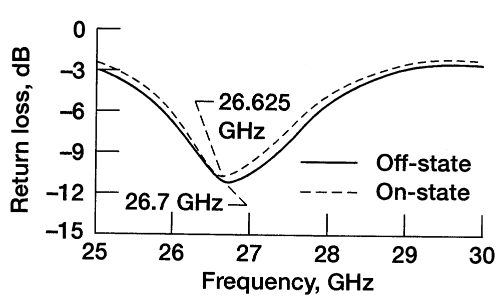

Figure 2.—Measured return loss.

Figure 3.—Computer controlled on-wafer CP radiation pattern measurement set-up using a rotating linearly polarized pick-up antenna for MEMS actuator based patch antennas (surrounding microwave absorber panels have been removed).

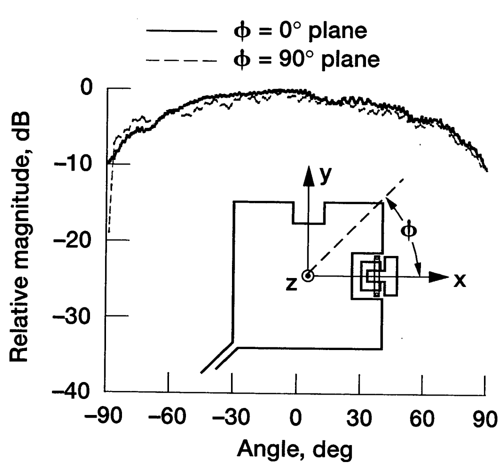

Figure 4.—Measured circularly polarized radiation patterns.

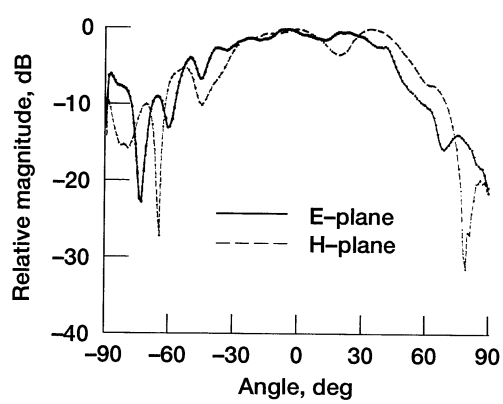

Figure 5.—Measured linearly polarized radiation patterns for vertical polarization.

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13. ABSTRACT ***(Maximum 200 words)***

The paper demonstrates a nearly square patch antenna integrated with a novel microelectromechanical systems (MEMS) actuator for reconfiguring the polarization. Experimental results demonstrate that at a fixed frequency, the polarization can be reconfigured from circular to linear.

14. SUBJECT TERMS

Microelectromechanical systems; MEMS; Circular polarization; Dual linear polarization; Patch antenna; Microstrip line

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